# Design and Development of Automated Filler Rod Feeding System for TIG Welding

**Ranbir Pratik Pradhan**
**(111ME0336)**

**Department of Mechanical Engineering**
**National Institute of Technology Rourkela**
**Rourkela-769008**
**Odisha,India**

# Design and Development of Automated Filler Rod Feeding System For TIG Welding

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By

**Ranbir Pratik Pradhan**
**Roll: 111ME0336**

Under the Supervision of
**Prof. Manoj Masanta**

**Department Of Mechanical Engineering**
**National Institute Of Technology Rourkela**
**Rourkela-769008**
**Odisha, India**

National Institute of Technology, Rourkela

# CERTIFICATE

This is to certify that the work in the thesis entitled "**Design and Development of Automated Filler Rod Feeding System for TIG Welding**" by **Ranbir Pratik Pradhan (111ME0336)**, has been conducted under my supervision required for partial fulfilment of the requirements for the degree of Bachelor of Technology in Mechanical Engineering during session 2014-2015 in the Department of Mechanical Engineering, National Institute of Technology, Rourkela.

To the best of my knowledge, this work has not been submitted to any other University/Institute for the award of any degree or diploma.

Date

Place-Rourkela

Prof. Manoj Masanta
(Supervisor)
Assistant Professor
Department of Mechanical Engineering

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**Ranbir Pratik Pradhan**

# DECLARATION

This is hereby solemnly and sincerely declared that the project and the thesis entitled "**Design and Development of Automated Filler Rod Feeding System for TIG Welding**" is a result of the combined effort of **Ranbir Pratik Pradhan (111ME0336)** and **Patil Gagan Shivadas (111ME0348)** of the Department of Mechanical Engineering, National Institute of Technology, Rourkela.

Prof. Manoj Masanta
(Supervisor)
Assistant Professor
Department of Mechanical Engineering

Patil Gagan Shivadas
111ME0348

Ranbir Pratik Pradhan
111ME0336

# ABSTRACT

Tungsten Inert Gas welding is a very effective welding process widely used in many industries for joining of sheets, stainless steel pipes, automobile parts and many other manufacturing processes. This welding process has an additional advantage of protecting the weld bead with the help of shielding gas or inert gas which avoids the oxidation of the bead, making the joint wear resistant and slag free. This has increased the demand of TIG welding extensively. Generally, it is done manually by holding filler rod in one hand and the TIG torch with other. Thus, the process requires a high amount of skill and human labour. Automation of TIG welding will not only reduce human labour but also improve accuracy. The project aims to develop and design an automated filler rod feeding system for TIG welding. To fulfil this purpose, a number of mechanisms are considered namely rack-pinion mechanism, slider-crank mechanism and screw-nut mechanism. The advantages and limitations of each mechanism are weighed against each other to decide the best mechanism that can be implemented. The mechanism is then designed and fabricated so as to fulfil the objectives of the project. It has also been ensured that the product at the completion of this project is industry oriented and has commercial value. After a rigorous analysis of the different mechanisms possible, screw and nut mechanism was chosen to be fabricated. A screw was made to rotate along a nut with the help of a motor. The motor shaft is fastened to the screw with the help of universal couplers. The filler rod is fixed to the screw with the help of a filer rod holder which is basically a cylindrical clamp. A slider is also provided to aid the movement of the motor with the screw. Finally, the whole setup is assembled on a Portable Moving Tractor, to which the TIG torch is also secured. The feeding of the filler rod is coordinated with the movement of the TIG torch. The suggested mechanism is one of its first in this particular field and can prove to be a worthy replacement of the presently used wire-feeding arrangement. With proper research in this area, it can be expected that better mechanisms and arrangements will emerge or materialize.

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# CHAPTER-1: INTRODUCTION

## 1.1 TIG WELDING

TIG welding or Tungsten Inert Gas welding, otherwise known as Gas Tungsten Arc welding is an inert gas shielded arc welding process. It is a homogeneous fusion welding. Here, the arc is formed between the non-consumable tungsten electrode and the base metal to be welded. The electrode is made up of pure tungsten generally mixed with 1-2 % of thorium oxide or 0.15-0.4 % of zirconium oxide. The weld metal is protected from atmospheric contamination by an inert shielding gas (argon or helium) and the use of filler material is optional. TIG welding can be divided into two types on the basis of electrode polarity-DCSP (Direct Current Straight Polarity) and DCRP (Direct Current Reverse Polarity). In reverse polarity, the electrode is positive, whereas in straight polarity, the electrode is negative. Heat generation at electrode and metal deposition rate is more in DCRP and is preferred in welding of thin sheets. Direct Current Straight Polarity, on the other hand, is mostly used for welding of thick sheets. But, straight polarity is generally not used for welding of Al & Mg alloys due to high temperature oxide formation. This limitation is overcome by using DCRP or AC welding. The arc blow in AC welding is insignificant but, at the same time, it is difficult to obtain a stable smaller arc.

The application of TIG welding lies mostly in the aerospace and automobile industries, especially in the welding of Al & Mg. TIG welding has proved to provide good quality weld depending upon the heat input. It also provides the operator greater control over weld area. Moreover, TIG welding can be performed in any position as the weld bead thickness is less. This provides an added advantage during the welding of metals with intricate designs. But, other than the operator’s skill, a good quality weld is mostly ensured by maintaining cleanliness of the equipment, especially the base metal or the work piece and the electrode. Rust, dirt, moisture and other impurities decrease the quality of weld. So, the operator should ensure that proper cleaning techniques are followed before the metal is subjected to welding.

Welding of thicker metals demands the use of filler materials. The quantity of the filler material depends on the base metal thickness. The feeding of filler rod depends upon its rate of consumption. But, the movement of the filler material with respect to the electrode is difficult. In fact, manual TIG welding is itself one of the most difficult welding processes as one must maintain a short arc length and at the same time ensure that the electrode does not touch the base metal. The filler rod movement is generally done manually in most of the industries and workshops. Automation of the same will reduce human labour as well as increase accuracy. The project aims to design and fabricate a mechanism to automate the process of filler rod feeding in TIG welding.

## 1.2 TIG WELDING SETUP

The TIG welding setup mostly consists of a power source, tungsten electrode, a TIG torch, shielding gas cylinder and a TIG unit with incorporated control systems. The use of filler rod is optional in this form of welding. But, in welding thicker sections, addition of filler metal is necessary. To generate an electric arc, a high frequency similar to tesla coil provides an electric spark. This spark acts as a conductive medium for the electrons to flow with the shielding gas and welding current is generated. This welding current leads to initiation of an arc whose stability will depend upon the amount of current and the distance between the electrode and the work piece. A brief description of the main components follows:

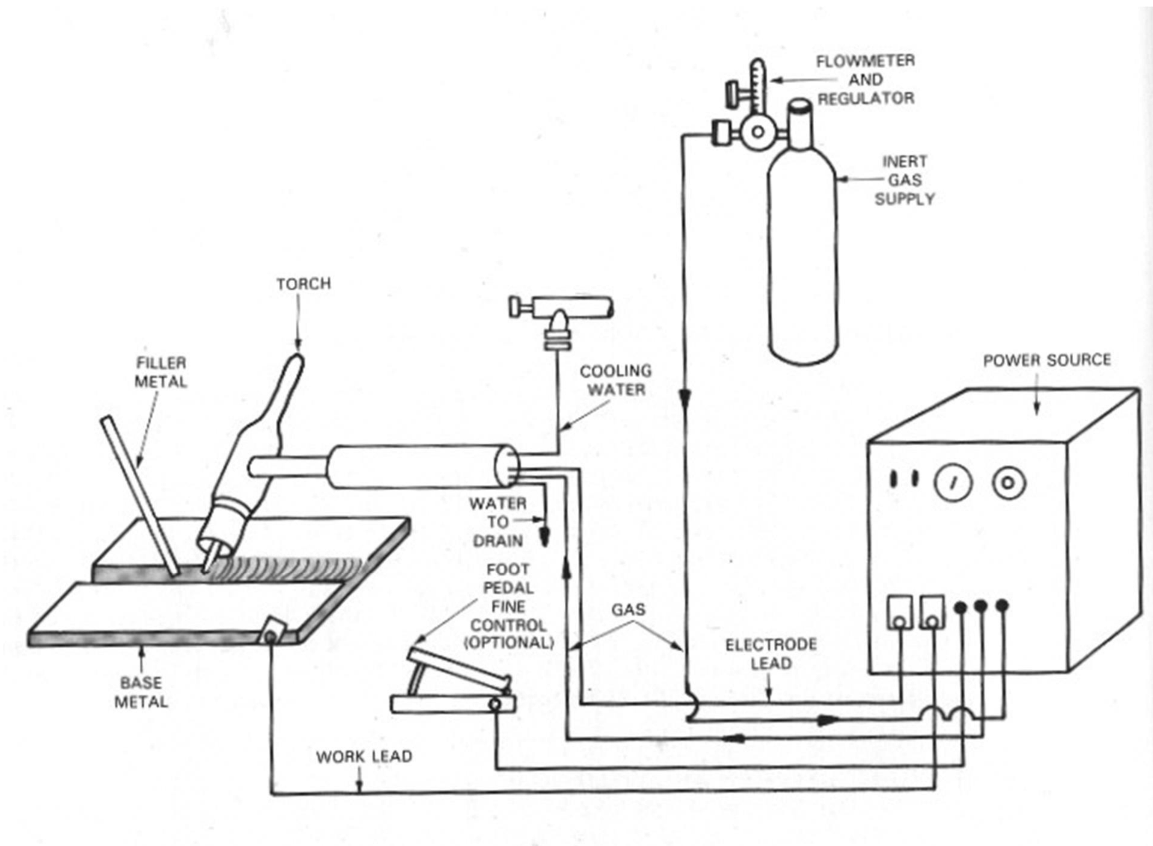


**Figure-1.1 TIG Welding Setup [Ref.: office.pickproducts.com.au]**

**TIG torch:** Its main purpose is to carry shielding gas and welding current. At the centre of the torch, tungsten electrode is attached. The inert gas is supplied to the welding zone through an annular path surrounding the atmosphere around the weld puddle. The torch handle is fitted with switch to turn the welding current and shielding gas on and off. They can be used for both manual and automatic welding operations with a basic difference in their designs. The size of the welding nozzle is decided by the amount of the shielded area required. The torch has connections to power supply and the shielding gas cylinder, and in some cases, it is also connected to water supply which acts as a coolant.

**Gas cylinder:** It provides continuous supply of argon or helium gas and also acts as a container for them. These gases act as shielding gases and are supplied with the help of cables connected to the torch. They protect the weld pool from atmospheric contamination. As the shielding gas is transparent, operator can clearly observe the weld.

**Power sources:** These are always of constant current type which means that the current will remain constant irrespective of the changes in arc distance or voltage. Thus, the heat generation will also remain relatively constant. Both DC and AC supplies can be used for TIG welding.

**Electrode**: Electrode initiates the arc acting as the element for closing the electrical circuit. It should be clean and free from contamination. Here, the electrode used is mostly made up of tungsten as it possesses high melting point and high electrical conductivity. The oxidation of electrode occurs to form tungsten oxide when electrode is allowed to cool in atmosphere after welding. It causes quick consumption of electrode by loss of metal in electrode tip. So, supply of gas should be continued for some time after welding to cool it properly.

**Filler rod:** It provides the filler material to be inserted in gap for welding. It is mostly made up of mild steel or stainless steel. The size of filler rod depends on base metal thickness. It is generally 1.5-3 mm in diameter.

# CHAPTER-2: BACKGROUND STUDY

## 2.1 LITERATURE REVIEW

| Name of Source | Name of Author | Journal of Issue/Publication Number | Year of Issue | Deliverables | Area of interest |
|---|---|---|---|---|---|
| Study of semi-automatic TIG welding. | S Honma and K Yasuda | Welding International, 18:6, 450-455 | 2004 | An investigation is done on the optimum conditions for semi-automatic TIG welding like wire diameter, feeding conditions, torch angle, wire feed angle and their effect on bead formation and workability during welding of various materials and joints. | Range of parameters needed to be controlled to get good quality welding |
| Influence of welding speed on tensile strength of welding joint in TIG welding process | Ahmed Khalid Hussain, Abdul Lateef, Mohd Javed, Pramesh.T | International Journal of Applied Engineering Research, Dindigul, Vol. 1, No 3 | 2010 | An investigation is done on the effect of welding speed on the tensile strength of Aluminium AA6351 alloy having a single v butt joint with different bevel angle and bevel heights when subjected to TIG welding. | Optimal welding speed for the welding of Aluminium in TIG welding |

| | | | | | |
|---|---|---|---|---|---|
| Forwarding a rod for use in welding by high pressure injection | Clarence H. Drader | US 6302309 B1 | 2001 | A feeding device is suggested for forwarding a thermoplastic rod into a hot pressurized chamber for forming a weld between two plastic parts. | Application of the feeding mechanism used for forwarding of the thermoplastic rod in the feeding of a filler rod |
| Guide mechanism | Shigekazu Nagai, Masahiko Someya, Hiroyuki Shiomi | US5711611 A | 1998 | A linear guide mechanism for the movement of a work piece has been suggested, consisting of an array of rollers supported on guide block acting as roller bearings, which are incorporated in a linear actuator. | Mechanism of a linear motion track to provide smooth linear movement to a load |
| Manual welding wire feeder | Thomas Guinn Langley | US5782394 A | 1998 | An apparatus is disclosed for the continuous feeding of the filler wire to the seam being welded so as to provide better wire tip stability and to improve the quality of the weld. | Present invention available for manual but continuous feeding of filler wire |

| | | | | | |
|---|---|---|---|---|---|
| Wire feed control assembly | Mark R. Christopher, Jim Maynard, Jerry Piechowski | US7465902 B2 | 2008 | The suggested wire feed assembly consists of a motor to automatically feed the wire and the motor is connected to a controller with a knob to facilitate the operator's adjustment. | Control system for an automatic wire feeding mechanism |
| TIG welding system and method | Richard Mark Achtner, Bruce Patrick Albrecht, LeRoy H. Lauer, Jr. | US 8026456 B2 | 2011 | It suggests an advanced welding setup consisting of a welding gun coupled with a wire feed giving more control to the operator. | Advancement in automated welding techniques especially automated filler feeding. |
| Effect of Pulsed Current on Temperature Distribution, Weld Bead Profiles and Characteristics of GTA Welded Stainless Steel Joints | N. Karunakaran | International Journal of Engineering and Technology, Vol. 2, No. 12 | 2012 | A comparison is made on the effect of pulsed current and constant current welds on different physical properties and micros structural features of stainless steel. | To understand the functioning and application of Lincoln Electric TIG Welding used in the journal paper |
| Prediction of the weld pool geometry of TIG arc welding using fuzzy logic controller | H. K. Narang, U. P. Singh, M. M. Mahapatra and P. K. Jha | International Journal of Engineering, Science and Technology, Vol. 3, No. 9 | 2011 | A list of TIG welding process parameters were considered to predict weld pool geometry using fuzzy logic simulation | To understand the functioning of TIG welding setup integrated with Linear Variable Displacement Transformer(LVDT) |

## 2.2 MOTIVATION

The motivation for the project comes out of the different constraints of manual welding operation. Moreover, a high quality manual TIG welding can only be performed by a skilled operator and with the demand for skilled welders ever increasing, the need of hour is to think of an alternative solution which can provide high quality welding with least effort and minimum skill requirements. Safety is another concern that cannot be ignored. TIG welding, like many other welding operations, can prove to be dangerous if proper precautions are not taken. Thus, automating the process will make it safer and reduce human labour without compromising with accuracy. Filler rod feeding is an important part of this welding operation, especially while welding thicker sections. It is generally done manually in most of the industries and workshops. The user holds the torch in one hand and filler rod with his other. This manual process requires too much skill and accuracy for proper weld beads with continuous uniform feed of filler rod. It is difficult for user to feed the filler rod by his hand simultaneously while performing welding. The project aims to design and fabricate a mechanism to automate the process of filler rod feeding in TIG welding.

At present, the only available automated filler rod feeding arrangement is the use of wire feeding apparatus [Langley, 1998]. But, the non-availability of filler wires and the inability of the apparatus to use thicker rods have restricted its use. It is hoped that the suggested mechanism at the completion of this project will be able to remove the drawbacks of the wire feeding arrangement.

## 2.3 OBJECTIVES

- The objective of the project is to design and fabricate an automated filler rod feeding system for Tungsten Inert Gas Arc Welding.
- The suggested mechanism should be economically feasible and should preferably have commercial value. It should also be serviceable and repairable in case of any defects.
- It should be able to overcome the drawbacks of the existing mechanisms like wire feeding arrangements.
- It should not compromise with the accuracy of the welding. In other words, the proposed arrangement should be able to provide high quality welding with minimal cost to the user.
- The filler rod feeding mechanism should be versatile in nature i.e. it should not be specific to a particular diameter or size of filler rod. It should give the operator the flexibility to use rods of different sizes with minimal changes to the setup.
- The arrangement or the setup should not be very bulky in nature and should preferably be portable. Moreover, the assembling and disassembling of the setup should be easy.
- It must require minimum skill to operate.
- Power consumption must not be very high as compared to manual TIG welding. In other words, operating cost should be low.

# CHAPTER-3: METHODOLOGY

## 3.1 EXPERIMENTS CONDUCTED

To develop an automated feeding system for filler rod, it is very essential to know accurate value of the rate of consumption of filler rod in normal TIG welding. There are mainly two types of motion in TIG welding:

1. Torch movement in horizontal direction which moves with constant welding speed
2. Filler rod consumption that is movement of filler rod.

To control the torch movement, an automatic guided vehicle is used which is already which is basically a Portacut machine on a linear rail.

**PORTABLE MOVING TRACTOR (PMT):** It is an electrically operated machine which has a cubical body having four wheels connected to it. The PMT is named Messer Portacut and it comes with a rail track of 1200 mm long. It moves linearly on this specified track with constant speed. Its functions are controlled by forward/off/reverse switch, clutch lever and speed adjustment knob. Torch can be fitted to the machine with screws and nuts so that it can move linearly with the same speed as that of machine. The knob provided on the machine determines the speed. By rotating it, speed can be increased or decreased. The speed adjustment knob consists of 10 speed levels. The level 1 corresponds to the slowest speed while the level 10 corresponds to the highest speed. The proper welding speed will come between level 2 to 5. Also, direction of motion can also be changed (forward or backward) by another lever type switch provided at the corner of machine which can be moved left or right. The speed of PMT can be varied according to requirement of welding speed, amount of heat required and rate of deposition. The torch tip and filler rod are to be aligned at very precise angle so that proper heating of metal takes place resulting in uniform bead size. So, objective is to synchronise the feeding of filler metal with the speed of PMT.

**Figure-3.1 Portable Moving Tractor (PMT)**

- **Speed calibration of PMT under no load condition**

1) The PMT is switched ON and it is moved at speed dial 1.
2) Two points at a distance of 15cm is marked on the rail track.
3) As soon as the PMT crosses the first point, the stopwatch is started and stopped as the PMT reaches the second point.
4) The process is repeated at rest of the speed dials.

<u>Speed Calibration Table</u>

**Table-3.1**

| Speed dial/knob level | Speed value(mm/s) |
|---|---|
| 1 | 2.5 |
| 1.5 | 3 |
| 2 | 3.50 |
| 2.5 | 4.0 |
| 3 | 4.5 |
| 3.5 | 5 |
| 4 | 5.5 |
| 4.5 | 6 |

- **Experiment for speed calibration of PMT during welding**

1) The speed adjustment knob is placed at speed dial 3.
2) A 15cm mild steel plate is placed below the tip of the torch connected to the PMT.
3) The PMT is started. It is ensured that the TIG welding is powered OFF.
4) As an arc is produced between the electrode and the work piece, stopwatch is started.
5) The observation is noted as soon as the electrode tip leaves the plate.

<u>Speed at dial 3 during welding</u>:

**Table-3.2**

| LENGTH | TIME | SPEED |
|---|---|---|
| 15cm | 35 sec | 4.3 mm/sec |
| 15cm | 38 sec | 3.9 mm/sec |

The speed of PMT at speed dial 3 was found to be around 4 mm/sec.; similar experiments can be done to determine the speed of the speed dial during welding at other knob levels. The PMT carries an extra weight of the welding torch and the feeding arrangement on a single side. Hence, it is very likely that its speed will vary from that of no load condition.

- **Experiment to determine filler rod deposition/decomposition rate**

An experiment was carried out to determine consumption rate of stainless steel and mild steel filler rod. For this, a sample work piece is kept under a torch to perform welding. Feeding of filler rod was done manually with hand. Initially, the main switch of PMT was switched ON. The speed dial was kept at third position. The electrode tip was kept at a suitable distance from work piece to cause continuous arc. When electrode tip crosses one end of the workpiece then stopwatch was started and time was stopped when it crossed the other end of the work piece. The experiment could also be conducted by stopping the welding at the completion of a minute. Finally, the filler rod deposition/decomposition rate was calculated:

Initial length of filler rod was measured accurately. After welding of 60 seconds, length was again measured.

Initial length of filler rod= 45 cm
Final length of filler rod= 28.8 cm
Consumption rate= 45- 28.8= 16.2 cm per minute.
Voltage = 16.8 V
Current = 53 A

A similar experiment was carried out with mild steel filler rod just to check any variation in values.
In that case, observations were:
Initial length of filler rod= 28 cm
Time of welding = 37 seconds = 0.616 min
Final length of filler rod= 16.5 cm
Rate of consumption = (28- 16.5)/ 0.616 = 18.64 cm per min.
Voltage = 17.5 V
Current = 52 A

So, if we take average of two final values obtained by two different types of filler rods, we get, consumption rate= 17 cm per min. According to this value, further calculations were done for various mechanisms suggested.

## 3.2 FEEDING MECHANISMS

To get over the disadvantages of wire-feed mechanisms, three mechanisms were suggested:

1. Slider-crank mechanism
2. Rack-pinion arrangement
3. Screw and nut mechanism.

A detailed description of the three mechanisms is as follows:

**SLIDER-CRANK MECHANISM:** In this mechanism, a slider which is operated by a rotating crank is used to feed the filler rod by attaching the rod to the end of the slider. This slider moves to-and-fro on a single track when crank is rotated with the help of a connecting rod provide between the crank and the slider. This type of mechanism is mainly used in an internal combustion engine in which piston reciprocates according to crankshaft.

The crank can be rotated by electric motor or by using man power. Since, we need to automate this mechanism; the use of an electric motor is preferred. The motor will be connected to the crank. Gears may be used to reduce the rpm of the motor though it is preferred to use a low rpm motor. The speed of the motor may also be voltage controlled. On half rotation of the crank, the slider and in turn the filler rod will make a complete linear displacement. A filler rod can be attached to the end of a slider by some clamping mechanism. A possible arrangement is shown in the figure.

The main difficulties are maintaining low speed of the crank and the lack of uniformity in its motion. The filler rod should have a constant forward velocity compensating for its rate of decomposition. But, the slider will never have constant velocity in its path. At the extreme position of slider, it stops for some time known as ideal time. In this position, it has maximum acceleration. At each point on its track, it has some acceleration. So, for a constant feeding, this mechanism can never be applied. To make it work, motor speed driving the crank should be continuously controlled to make slider move with constant velocity, which is very difficult in practical sense.

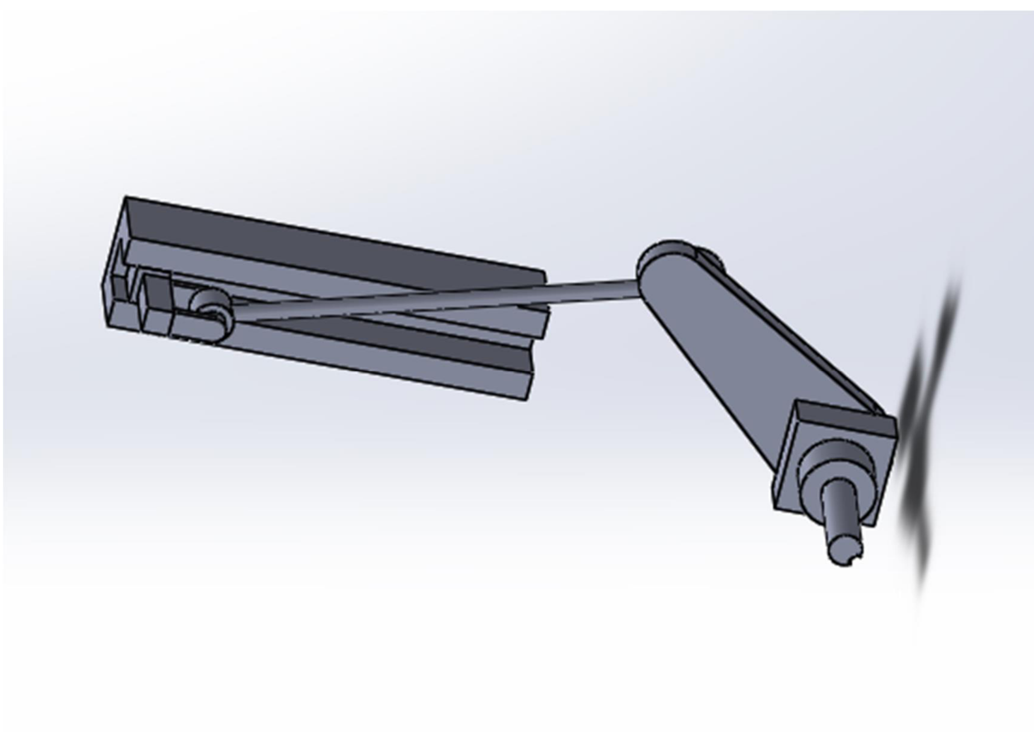

**Figure-3.2 Slider Crank Mechanism**

**RACK AND PINION ARRANGEMENT:** A rack and pinion is a type of linear actuator that comprises of a pair of gears which converts rotational motion into linear motion. A circular gear called pinion engages or meshes its teeth with that of a linear gear. The rotational motion of pinion by external motor causes rack to move with a constant velocity. A filler rod can be attached at the end of rack for constant feeding. The velocity of rack should be equal to the consumption rate of filler rod.

Velocity of rack= V = 18 cm/ min which is the closest value to the average rate calculated before.

Also, we know, W*R= V
Where R= radius of the pitch circle of the pinion; W= angular velocity of the pinion.
Thus, R = V/W
Taking W= 2 rpm which is the lowest rpm that is generally available for any motor
W=2 rpm= (2*2π)/60 radians/sec.
And, V= 18 cm/min= 0.003 m/s.
Putting these values , we get, R= 0.003/(π/15) = 14.33 mm. = 1.433 cm.
Assuming module of pinion= m= 1.25mm
T= number of teeth on pinion = D/m = (2*R)/m = (2*14.33)/1.25= 22 approximately.

These calculations are done taking into consideration the minimum rpm that can be possible for motor. If we increase the motor speed, then R will decrease keeping the velocity of rack constant. This pinion with decreased radius will be very difficult to manufacture with 22 or more number of teeth. A lot of skill and hence cost will be required to make a single pinion.
Apart from this, a lot of drawbacks of this method can be possible that can be listed as follows:

1. Components like rack and pinion of exact size and meshing are too costly to buy. It is not affordable for our project.
2. For better and smooth performance of rack-pinion, they should be made up of hardened materials like stainless steel, mild steel or cast iron. This will make the whole assembly heavy and bulky.
3. While feeding, the rack may accelerate due to its own weight as rack will be in inclined position. This acceleration due to gravity will prove to be a detrimental factor for constant velocity feeding.

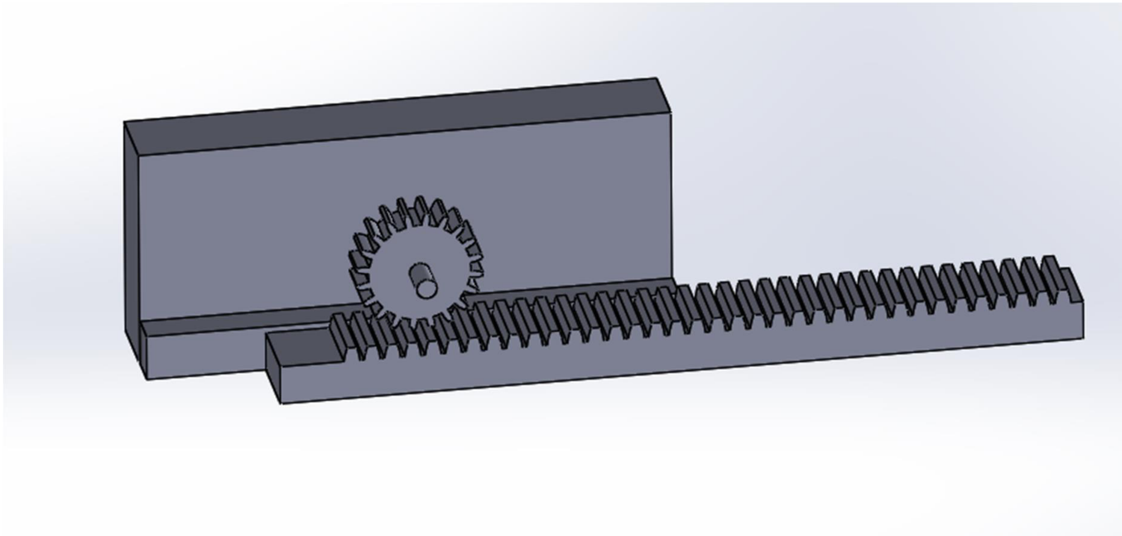

**Figure-3.3 Rack and Pinion Mechanism**

So, this method can be feasible but its limitations outweigh its advantages.

**SCREW AND NUT MECHANISM**: In this mechanism, linear feeding is provided by movement of screw at the end of which filler rod is connected by clamping mechanism. The screw passes through a nut which is fixed to the frame of PMT. The rotary motion of screw required for its linear displacement is given by connecting it to an external electric motor. The motor's output shaft will be connected firmly to the screw so that it rotates with the same rpm as that of motor. With one revolution of the motor, screw passes by a distance equal to the pitch of the screw. To make the motor move with the screw, a proper linear guide has to be provided for motor. As the filler rod gets consumed, the motor will also move linearly with the screw to compensate this consumption with the help of linear guide. But, the displacement of the filler rod is restricted to the length of the screw. The guide, motor and screw should be oriented in the proper direction so as to reach the torch tip at a suitable angle.

There are many advantages to this method:

- Components required for working of this mechanism can be available anywhere and also in the affordable rates.
- The linear motion of screw has the constant velocity all the time and it will not be affected by gravity as the motion will always be restricted to the engagement with the screw.
- There is always an upward normal force on the motor shaft along its axis exerted by the screw. This force prevents sliding of the motor due to gravity.

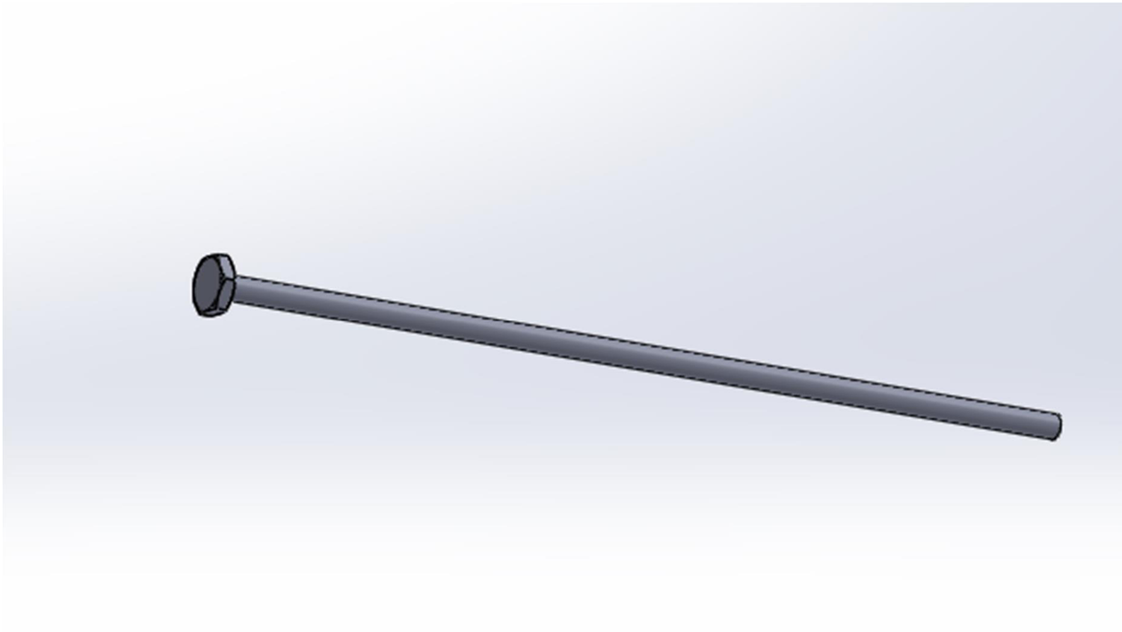

**Figure-3.4 Screw and Nut Mechanism**

**Figure-3.5 Screw and Nut Mechanism [Ref.: www.buildyourcnc.com]**

# CHAPTER-4 RESULTS AND DISCUSSION

Due to mentioned advantages of a screw-nut mechanism over other two suggested mechanisms, it was finalised to be worked out for feeding of filler rod. For this, the list of components required is as follows:

1. **Bolt and nut**: A long bolt of length approximately 30 cm and the corresponding nut of the same threading are taken. The pitch of the screw varies from 0.8-1 mm. The nut is to be fixed to the assembly with a proper alignment. The length of the bolt is decided by the length of the filler rod. Moreover, the lower the pitch of the bolt, higher the rpm of motor is required.

2. **Motor**: It consists of a 12V DC motor which has a separate AC-DC adapter provided. This adapter has a knob on it which can be used to vary the input voltage of motor from 0V-12V by rotating it. This controls the motor rpm. Motor moves linearly with a distance equal to the pitch of the screw in one rotation.
   As consumption rate is approximated to be at 18cm/min, motor should move 18 cm distance in one minute. For this to happen, total number of revolutions required per minute = (Consumption rate/ pitch of screw)
   Assuming pitch be 0.8 mm= 0.08 cm, 18/0.08 = 225 revolutions per minute.
   As the pitch varies from 0.8 -1 mm, the average rpm of the motor can be assumed to be at 200 rpm.

3. **Couplers**: These are also known as universal couplers and are used to connect the motor shaft to the screw. Their assembly with the electric motor is shown in figure 4.1. Each coupler has a central big hole and many small holes on its face. The two couplers can be connected to each other by inserting bolts in all the holes. Through the big hole of one coupler, motor shaft is inserted and through another hole, screw is inserted. And then both the couplers were connected firmly to each other as shown in figure 4.2.

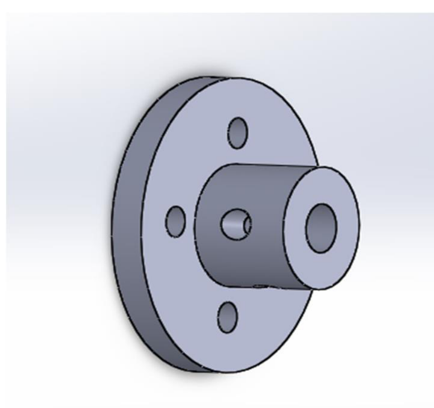

**Figure-4.1 Coupler**

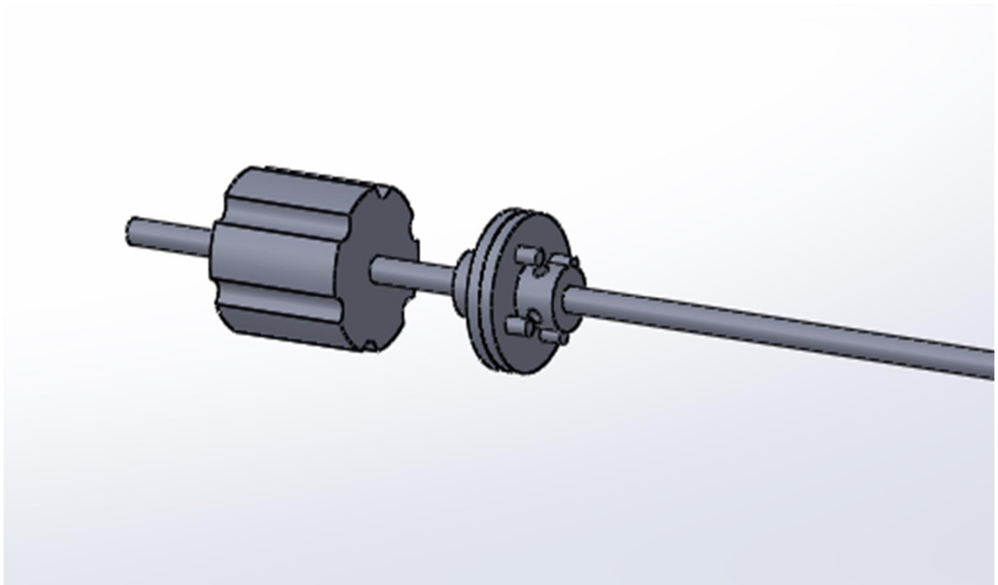

**Figure-4.2 Motor coupled to the screw**

4. **SLIDER-RAIL:**

As mentioned earlier, motor will require linear guide for feeding. For this, a slider-rail was used. Linear guides are a set of components that are used to achieve precise linear motion. They consist of a block that slides smoothly on a rectangular rail. For this project, both slider and the rail are manufactured by using the rapid-prototyping technology. It manufactures a physical model by using computer aided design (CAD) data. Construction of the part is usually done with 3D printing "additive layer manufacturing" technology. The reasons behind using this technology are:

1. It is impossible to buy the sliders from market due to its rare availability and extremely high prices.
2. In RP, customization can be easily done and manufactured.
3. Model material used is Acrylonitrile Butadiene Styrene plastic which has reasonably high strength, impact resistance and toughness which fulfils our requirement.
4. Raw material used in RP doesn't get corroded or wears out easily. Hence, it has very long service life.

The slider and the rail are fabricated simultaneously but as different parts in the rapid prototyping machine. It needs to be ensured that the dimensions of slider and rail lie within the range of the rapid prototyping machine bed. The procedure to manufacture a slider-rail by rapid prototyping is as follows:

1) The Solid Works file of the model is generated with proper dimensioning.

2) It is saved as a STL file which is processed, meshing and orienting the model for the build process. Support structures are generated.
3) The model or parts are produced by extruding small beads of thermoplastic material to form layer.
4) The thermoplastic material is supplied to a nozzle by unwinding from a coil. The rate of supply of material to the nozzle is controlled by a worm-drive mechanism. The nozzle is heated.
5) The nozzle's movement is controlled by NC mechanism. The part is built from the bottom up based on a CAM software package.

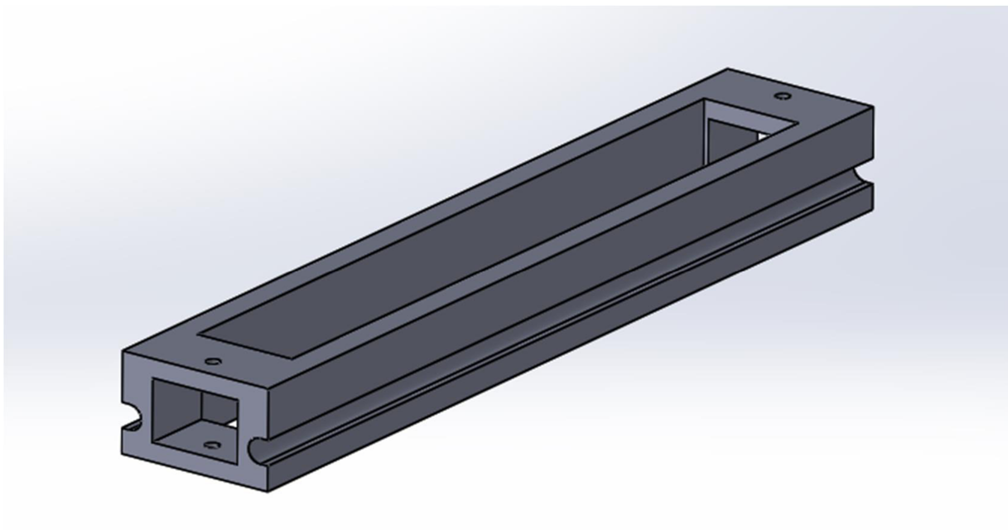

**Figure-4.3 Slider rail**

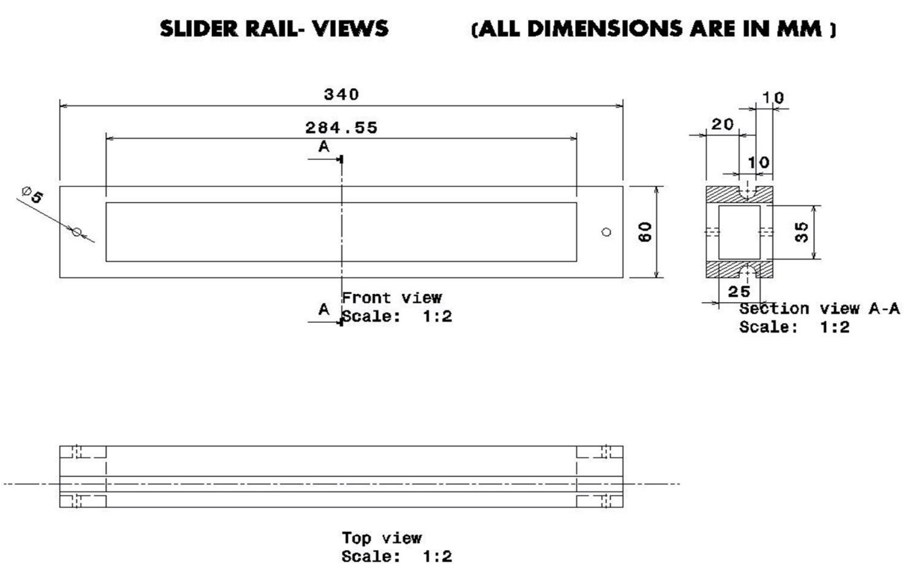


**Figure-4.4 Projection views of slider rail**

**Specifications of slider rail-**

1) Length=34cm
2) Effective sliding length=30cm
3) Two pockets of M5 bolt are done on each side of the rail at a distance of 1cm.
4) Material=Thermoplastic
5) Groove radius=5mm
6) Width=6cm
7) Edge thickness=1cm

**Specifications of slider box-**

1) Width=8cm
2) Length=7cm
3) Thickness=1cm
4) Height=4cm
5) Approximate load=150-200g(motor weight)
6) Material=Thermoplastic

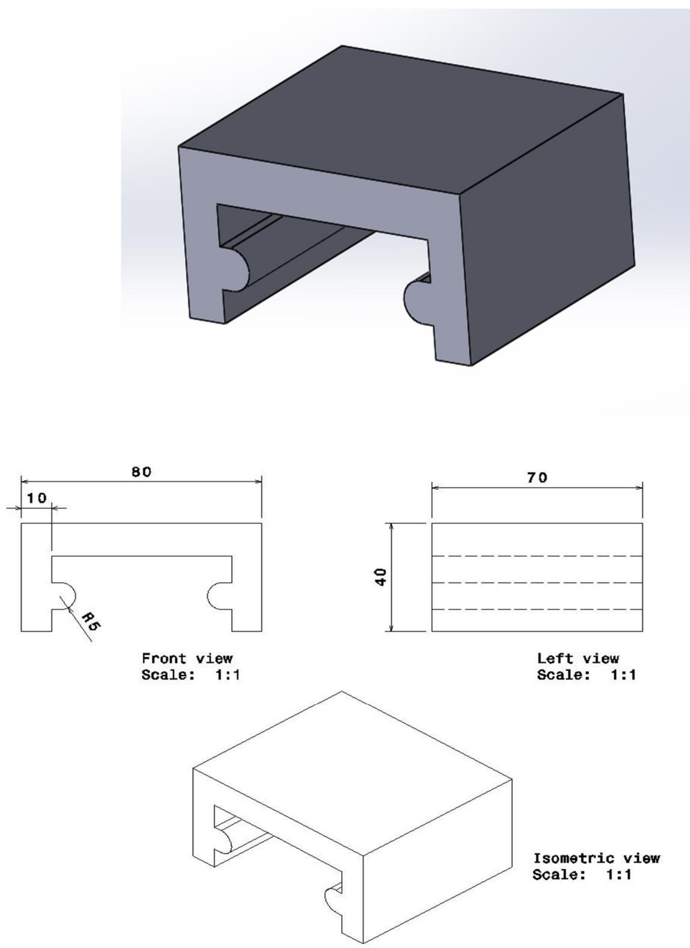


**Figure-4.5 Slider box**

5. **Modified PMT-** Portable Moving Tractor design was modified so that it can sustain the load of whole assembly of mechanism. As shown in the figure 4.6, two supports were separately welded to the main frame to give sufficient support to the slider rail by inserting M5 bolts between them. Also, the nut through which the bolt passes is separately welded taking into consideration the coincidence of nut to the torch tip and the alignment of the bolt with the nut.

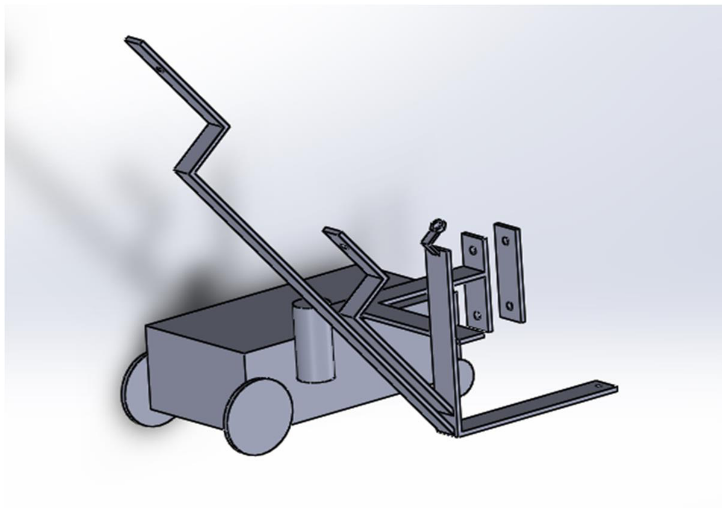

**Figure-4.6 Modified PMT**

6. **Filler rod holder-** The filler rod is fixed to the bolt with the help of a cylindrical clamp. A piece of thick rod around 1.5 cm in diameter is cut to act as the filler rod holder. The cylindrical clamp has internal threading identical to that of the bolt which aids in its assembling and disassembling. Thus, one side of the clamp will be assembled to the main bolt through a hole of diameter 1cm while the other side with a hole of about 3mm diameter and 1cm long will be free for the filler rod to be fixed. To make best fitting of this filler rod, the clamp is provided with two diametrically opposite holes through which two bolts can be inserted that fit the filler rod in between them and keep it always at the centre of the hole. The maximum diameter of the filler rod that can be clamped is approximately 3mm.

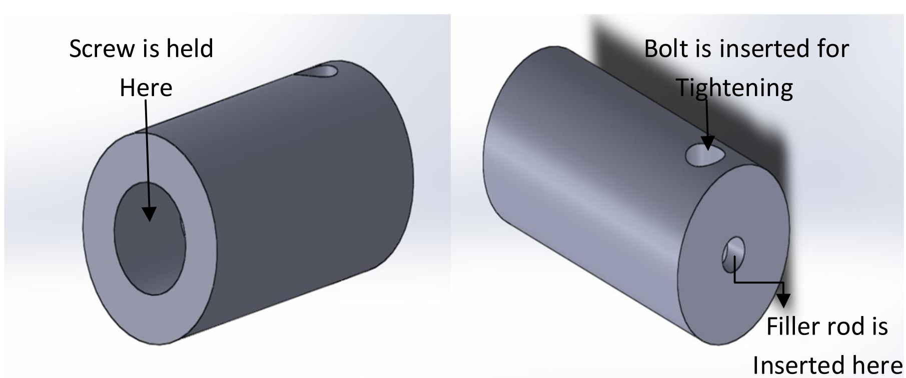


**Figure-4.7 Filler rod holder**

# FINAL ASSEMBLY

All the components including the motor, bolt, slider, filler rod holder and filler rod are assembled with the PMT as shown in the figure 4.7 and 4.8.

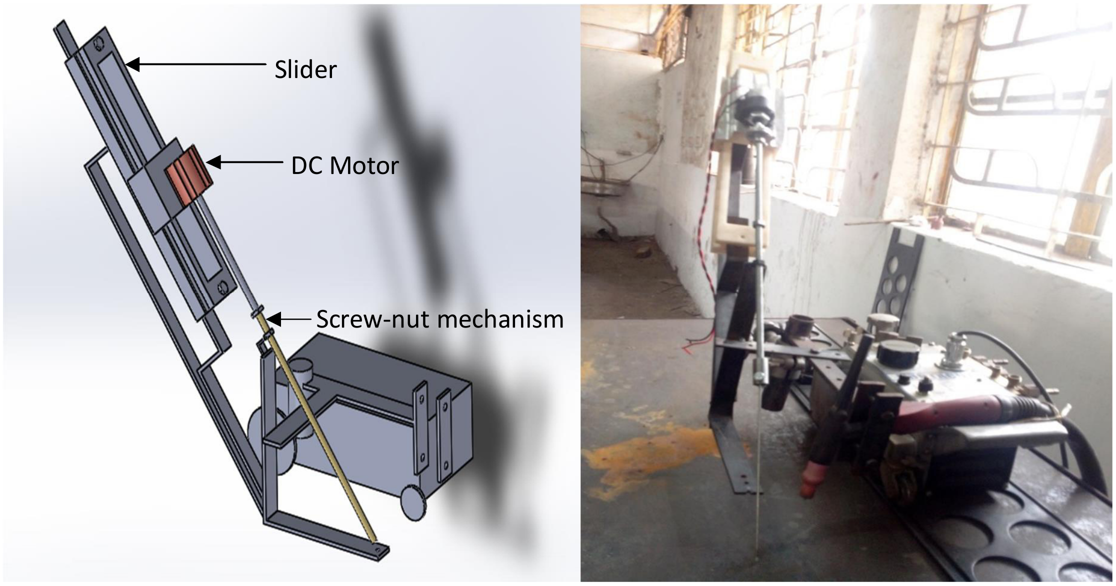


**Figure-4.8 Isometric view of the final assembly**

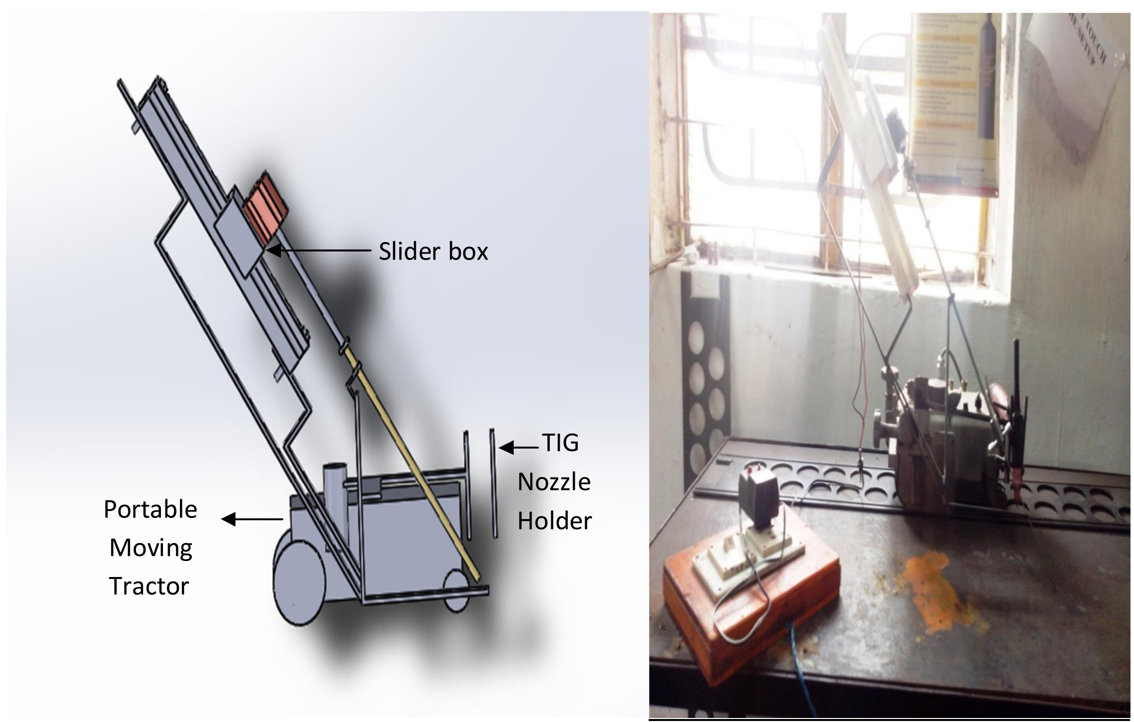


**Figure-4.9 Side view of the final assembly**

# CHAPTER-5 CONCLUSIONS AND FUTURE SCOPE

Research on this topic is expected to open new doors in the field of filler rod feeding mechanisms. Most of the present inventions are based on wire feeding mechanism. But, the use of a filler rod instead of filler wire may bring some significant changes in industrial welding practices. Moreover, the following invention is not limited to the feeding of filler rod only. In fact, the screw and nut mechanism proposed here can be used to provide motion to any kind of rod. In many cases, such as high pressure injection welding, rolling and in many other primary and secondary manufacturing processes, feeding of some kind of raw material is required. The mechanism discussed here can cater to this requirement by providing an automated arrangement for the same. But, much work needs to be done in this area before these types of arrangements can be inducted in industries.

The following feeding mechanism can also find its use in TIG cladding. Cladding is an effective process against corrosion and wear. In the process, a layer of weld metal is clad on the base metal. The material characteristics and properties of this weld metal are generally different than the base metal. This weld metal can be fed to the work piece by using the screw and nut mechanism proposed here. The Though, the following apparatus is not exclusively designed for its use in an arrangement for filler rod feeding in TIG welding, at present, the discussion shall be restricted to its use and future scope in TIG and related welding processes only.

With the demand of labour increasing and companies trying to increase the rate of their mass production, the automated filler rod feeding system will surely find its way for use in industries. Currently, the available feeding system is mostly wire based restricting its deposition rate, as wires have smaller diameter compared to rods. Moreover, most of these filler wires are specially manufactured or compatible to a particular type of wire feeding system which restricts its use to a large extent. But, the automated filler rod feeding system discussed here is more versatile as it can be used for almost all types of filler rods with slight modifications in the apparatus. This type of arrangement helps when the deposition rate varies or when different materials are needed to be welded with their corresponding filler materials.

The present arrangement consists of a Portable Moving Tractor which provides forward and backward motion to the whole assembly. But, the distance it can cover is limited as it is dependent on the length of rail. Moreover, it can only provide linear motion, making it difficult to weld curved plates. The angle between the filler rod and the torch is also almost constant. Depending on the welding voltage, one may need to change the angle between the electrode tip and the filler rod. These are some of the open problems that need to be solved with further improvements in design.

A possible arrangement can be designing a table or base for the work piece whose position can be controlled in the three major axes. The table may also provide the flexibility to the operator to weld the work piece at an angle. One may also find the apparatus used here as bulky. With proper design considerations, its size can be reduced. The screw and nut mechanism used here for the automation of the filler rod in TIG welding is only one of the many mechanisms possible and may not prove to be the best also. If proper attention is given to this field and enough research is done in this area, new and more viable mechanisms will come into light.

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